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# Testing Attitudes to Short-Term Risk for Abdominal Aortic Aneurysm Scenarios

I.M.F. Taylor, MRC student

Sheffield Health Economics Group, ScHARR, University of Sheffield, Regent Court, 30 Regent Street, Sheffield, S1 4DA.
Tel: 0114 2220722

E-mail: cmp98imt@sheffield.ac.uk

Supervisor:

Professor John Brazier, Sheffield Health Economics Group, University of Sheffield.

Clinical advisor:

Mr Steven Thomas, Sheffield Vascular Institute, Northern General Hospital, Sheffield.

## Abstract

QALY valuations were compared with a direct method of valuing health profiles, testing the axioms of the QALY algorithm. The QALY is the most commonly used evaluation tool, and violations of the underlying axioms could lead to misdirections of health care resources.

Sixty-one staff, students and patients were recruited from the University of Sheffield and a local hospital to complete a time trade-off questionnaire, in which they valued two scenarios and their constituent health states, and also indicated their risk attitudes and time preferences. The scenarios were over life expectancies of two and three years. They both contained risk of mortality/morbidity, but the three-year scenario contained greater risk.

The QALY method gave consistently higher mean values for both scenarios than the direct method. On average the sample was risk seeking ($r=1.21$, where $r<1$ indicates risk aversity, $r=1$ indicates risk neutrality, and $r>1$ indicates risk seeking). However, higher mean values for the two-year, less risky scenario indicate that utility gained by increasing life expectancy by one year was outweighed by disutility from risks of mortality/morbidity.

These results indicate that even risk seekers will show risk aversity, refusing to maximise short-term life expectancy if there are significant *ex ante* risks. This leads to a violation of the QALY axiom of constant attitude to risk.

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## Introduction

This study aims to determine preferences between scenarios offering longer life expectancies with high associated risks, and shorter life expectancies with lower risks. This will test the underlying axioms of the QALY axiom, such as assumptions concerning risk attitude. The QALY algorithm is compared with a direct valuation of these scenarios.

## Background

*Abdominal aortic aneurisms*

An abdominal aortic aneurysm (AAA) occurs when the wall of a vein or artery becomes dilated (Loyola University, 1999). AAAs are dilations greater than 30 mm in diameter, and mostly occur within the infrarenal aorta (Calvert *et al*, 1999). If left untreated, they are likely to expand and eventually rupture. Rupture rates are related to AAA size. It is estimated that the rate of rupture of AAAs of 40 – 50 mm is 3 – 12% over five years, whereas the 5-year rupture rate for AAAs of over 50mm is estimated to be within the range of 25 – 41% (Calvert *et al*, 1999).

Once the AAA has ruptured, the individual has a very high probability of bleeding to death. Studies have reported hospital pro-rupture mortality rates range from 40-80%, but since many cases of rupture occur outside hospital this figure may be as high as 95% (Thomas, 1999; Thomas and Stewart, 1988; Budd *et al*, 1989; Ingoldby *et al*, 1986; Johansson and Swedenborg, 1986; Campbell *et al*, 1986; Bengtsson and Bergqvist, 1993; Kantonene *et al*, 1999; Eskandari *et al*, 1998). The incidence of ruptured AAAs was recently reported as between 1 and 21 per 100,000 per year (Calvert *et al*, 1999), although it is likely that many go unreported due to the asymptomatic characteristic of smaller AAAs.

There has been recent interest in comparisons between different treatments for AAAs. Two clinical trials began at the end of 1999, which are examining the cost-effectiveness of different treatment options (Calvert *et al*, 1999). The two trials are called EVAR (endovascular aneurysm repair) I and II, with EVAR I comparing conventional open surgical repair to endovascular stent grafting in patients fit for open surgery and EVAR II comparing endovascular repair with best medical treatment in patients deemed unfit for surgery. The endovascular procedure is a minimally-invasive technique.

Thomas (1999) used a Markov design study to show that it was cost effective (in terms of life years gained) to place stent-grafts in unfit patients. This result is interesting and possibly open to question, because the unfit patients would be taking an increased risk of death in the near future for a moderate gain in life expectancy. Although Thomas did not conduct a cost utility analysis, he looked at the possible effects of utility values on costs during his sensitivity analysis. He found that cost per QALY could be significantly altered depending on utility values following EVAR or best medical treatment (BMT). Thomas expressed the necessity to obtain utility values for unfit patients with AAA.

*The QALY assumptions*

The most commonly used measure of utility in cost utility analyses is the number of quality-adjusted life-years (QALYs) generated by an intervention. The QALY approach combines values of health-related quality of life (HRQoL) with information on length of life into a single index. The QALY model operates under several stringent assumptions of human decision-making behaviour. One of these underlying assumptions is that people have a constant attitude to risk, and in practice risk neutrality is usually assumed (Bleichrodt *et al*, 1997). However, many risks intrinsic to medical decision-making are not taken into account in most valuation studies. It has been shown that individuals do not conform to this assumption (Cook *et al*, 1994). A zero time preference is also assumed, and it is assumed that diminishing marginal utility (*i.e.* quantity effect) does not apply.

The present study compares the QALY algorithm with a direct method of valuing health profiles containing *ex ante* risks over a short life expectancy, such as are likely to be encountered by AAA patients. The QALY axioms of constant attitude to risk and zero time preference are examined.

The demonstration of cost-effectiveness is important for public funding of new health care interventions in some countries (Commonwealth Department of Health, 1992; Department of Health, 1994; Ministry of Health Ontario, 1994). Since economic evaluations affect allocation of health care resources, the importance of testing the accuracy of the methods used cannot be overstated.

**Methods**

Health scenarios were designed based on states associated with EVAR and the best medical treatment alternative (BMT). Descriptions of scenarios were based upon reviews of literature and internet sources (Cuypers *et al*, 1999; Walker *et al*, 1998; Thomas, 1999). The scenarios are shown in Figure 1.

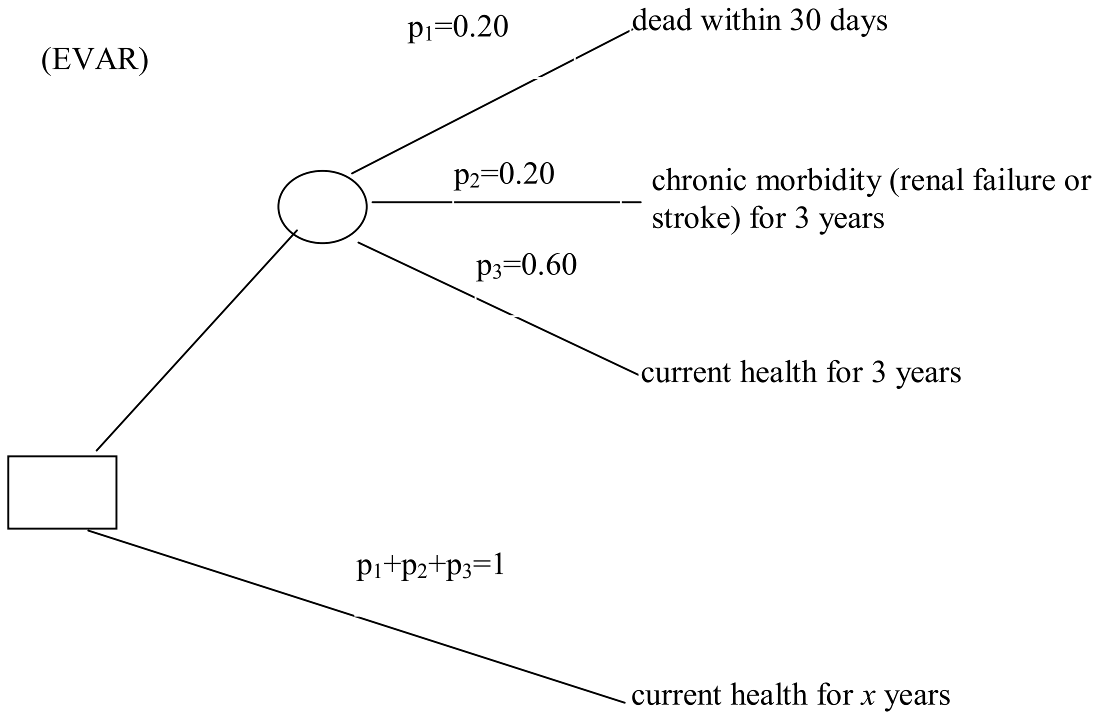
The EVAR scenario for an unfit AAA patient facing treatment by EVAR includes a 20% chance that the patient will be dead within 30 days, a 20% chance that the patient will suffer either chronic renal failure or stroke and will die after 3 years, and a 60% chance that the patient will survive in his/her current health for 3 years and then die.

The BMT scenario represents the probabilities faced by an unfit AAA patient facing best medical treatment (BMT). In this case, the patient faces a 2% chance of death within 30 days; a 0% chance of chronic renal failure or stroke; and a 98% chance of current health for 2 years followed by death. Death rates in Yorkshire and Humberside were used as a proxy for BMT 30-day mortality (HMSO, 1992).

Constituent health states were also constructed (familydoctor.org, 2000; American Academy of Neurology, 2002; American Heart Association, 2002; National Institute of Diabetes & Digestive & Kidney Diseases, 2002). Health states are shown in Figure 2.

During the design process the states and scenarios were shown to medical professionals at the Sheffield Vascular Institute. They concluded that the states and scenarios, although relevant to AAAs, were not specific to this condition. It was therefore feasible to use a convenience sample rather than endure the logistical difficulties of obtaining a sample of AAA patients to value the states and scenarios.

Because the scenarios contained risk, the probability-based standard gamble was not considered to be a suitable valuation method. Consideration of two dimensions of probabilities could have likely led to cognitive overload in the respondents. The certainty equivalent method was used to value the scenarios. This is synonymous



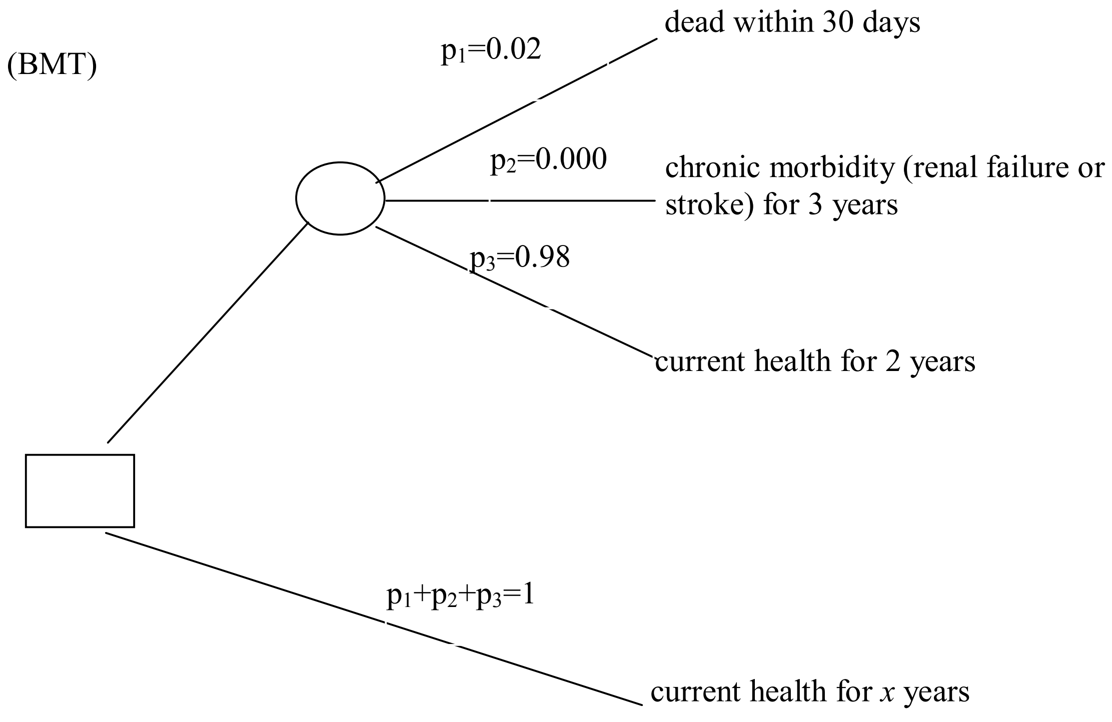




Figure 1 Presentation of the scenarios. The short-term mortality figure in the BMT scenario is derived from death rates in Yorkshire and Humberside (HMSO, 1992). The rest of the figures are derived from Thomas (1999).

Figure 2 Health states used in the study.

Chronic renal failure

You have to undergo dialysis, which means that a machine takes over the role of the kidney. This involves spending 3 hours in hospital 3 times a week. Alternatively, you might do dialysis at home, in which case you need a large storage space in which to keep all the necessary materials. This method involves serious restrictions on your lifestyle. For example, you have to interrupt your normal daily activities to go on dialysis. You also face restrictions on taking holidays.

You have restrictions on what you can eat and drink. For example, you are able to drink only a very moderate amount of alcohol. You are instructed to moderate your intake of certain foods, such as bananas, cheese, milk, and meat.

You feel tired and depressed for much of the time.

Stroke

You have sensory loss, so that you no longer have a sense of touch. You are also unaware of the positions of your affected limbs when you are not looking at them.

You have significant loss of the ability to speak.

Your sight is affected, so that the affected eye is no longer able to recognise familiar objects.

You have lost some control over your movements. This means that the limbs on the affected side of the body seem clumsy, and no longer do exactly what you want them to do.

You are subject to mood changes.

You are considerably more dependent on the help of others than previously.

with the time trade-off (TTO), so a TTO layout was used throughout the valuation of states and scenarios. The version of TTO used was that suggested by Gudex (1994).

Risk attitudes were estimated for each individual by use of a set of gamble questions derived from McNeil *et al* (1978), Miyamoto and Eraker (1985) and Stiggelbout *et al* (1994). This is a certainty equivalent (CE) method, in which respondents were presented with a gamble where there was probability $p$ of surviving 36 months in a given health state and a $1 - p$ probability of dying immediately. Each individual was asked to state the number of months lived in the given health state for certain which would be equivalent to the gamble. Certainty equivalents were obtained for $p = 0.25$, $p = 0.50$, and $p = 0.75$. These are referred to as CE25, CE50, and CE75 respectively. With this information it is possible to plot risk attitude curves.

The risk attitude ($r$) for each individual was obtained by the method suggested by Miyamoto and Eraker (1985), whereby

$X_n = \ln (n / 100)$

$Z_n = \ln (C_n / Y_{max})$

$n = 25, 50, 75$

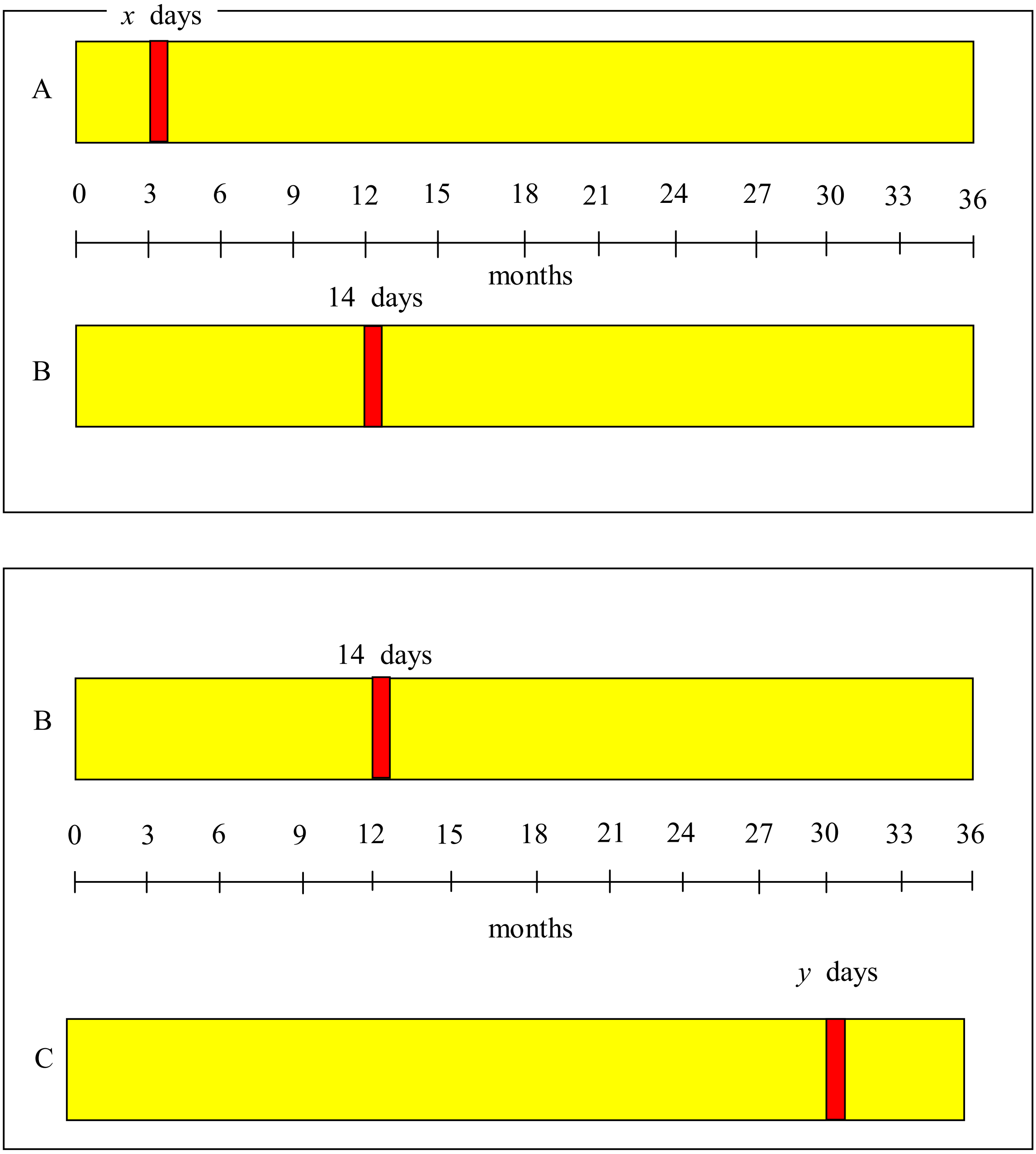
$C_n$ = CE over 25, 50, 75

$Y_{max}$ = 36 months

Time preference questions were based on the work of Cairns and van der Pol (2000), and adapted for this study. Figure 3 shows the two time preference questions in diagrammatical form. The dark strip represents a period of ill health (the Euroqol state 22222). The paler parts of the bars represent excellent health.

Respondents were asked which they would prefer of Scenario A or Scenario B. If they preferred A, they were asked how many days of good health they would be prepared to give up (or "pay") in exchange for receiving their preference. Thus if $x > 14$ for Q12(i), a negative time preference (*i.e.* preferring to have the bad earlier) is

Figure 3 The two time preference diagrams used in the questionnaire.



implied. If $x < 14$, a positive time preference is implied. Similarly, if $y > 14$ in Q12(ii), a preference for Scenario C is implied, thus suggesting a positive time preference. If $y < 14$, a negative time preference is suggested. Of course, a value of $x$ or $y$ that is equal to 14 implies a neutral time preference.

The questionnaire was administered in groups of one to 10 respondents by a trained and experienced interviewer (the author). The interviewer introduced herself and the project to respondents, explaining that all information divulged by them during the interview would be treated as confidential. She explained all the tasks to be performed during the interview. She then took them through the first valuation task in the questionnaire, explaining the procedure. They completed the rest of the tasks on their own. However, the interviewer remained in the room, and respondents had the opportunity to request further explanations as required.

The tasks are summarised as follows:

- Background characteristics (age, sex, occupation, age at completion of education)
- EQ-5D rating
- ranking the health states of full health, stroke, chronic renal failure, current health, and immediate death
- TTO valuations of current health chronic renal failure and stroke
- ranking scenarios BMT, EVAR and full health and immediate death
- certainty equivalent valuations of BMT and EVAR
- three questions to assess attitudes to risk over a 36-month period
- a time preference question

## Results

*Background characteristics*

A convenience sample of 61 respondents was recruited. Forty were employees or students at ScHARR, contacted by an E-mail asking for volunteers. Thirteen were dayward or secretarial staff from the Sheffield Vascular Institute, contacted by the consultant assisting with the study. Three were patients with peripheral vascular disease who had just had a procedure on the dayward, and 5 were friends or relatives of the author.

The mean age of the sample was 38.8 years (range of 19–70 years). The mean age at completion of full-time education was 22.2 years (range of 15 – 39 years). A total of 42 (68.9%) of the sample were female, compared to 19 (31.1%) males.

The sample was relatively healthy overall. Over 90% reported no problems with mobility, self-care, and usual activities, and over 80% reported no problems with pain/discomfort and anxiety/depression. A total of 42 (68.9%) gave their EQ-5D state as 11111, the best possible state. The mean EQ-5D score for current health was 0.95 (median=1.00).

Out of these 61 respondents, there were seven who gave responses that were too unclear to include in further analysis. Of the respondents remaining in the analysis, 19 gave a range of indifference (*i.e.* "=" in more than one box, or wide empty gaps between ticks and crosses). The midpoints were taken. The results were subjected to a sensitivity analysis in order to determine whether the results would have been significantly different over their range of answers.

*Health state values*

Table 1 shows the health state valuations for the 54 respondents included in the analysis. The equation $x/t$ was used for states better than death, and $-x/t$ was used for states considered worse than death. Thus valuations were constrained between –1 and +1.

*Scenario valuations*

The QALY scores for health scenarios were derived from trade-offs between constituent health states and full health, using equations (1) and (2). They are on a scale where 0 is equal to death and 1 is equal to full health.

BMT (0.02 * 0.000) + {0.98 * U (current health) * 2 years} (1)

EVAR (0.20 * 0.000) + {0.10 * U (chronic renal failure) * 3 years} + {0.10 * U (stroke) * 3 years} + {0.60 * U (current health) * 3 years} (2)

| Table 1 Health state valuations. | | | |
|---|---|---|---|
| | Current health | Chronic renal failure | Stroke |
| Mean | 0.94 | 0.46 | 0.05 |
| SD | 0.14 | 0.57 | 0.68 |
| 25th percentile | 0.97 | 0.31 | -0.76 |
| Median | 0.97 | 0.64 | 0.19 |
| 75th percentile | 1.00 | 0.85 | 0.60 |
| Minimum | 0.36 | -0.97 | -0.97 |
| Maximum | 1.00 | 0.97 | 0.97 |

The direct valuations were derived from trade-offs between the scenarios and current health, and therefore had to be chained through current health to full health before a true comparison could be made between the direct and QALY valuations. The calculation for chaining to full health is $U_3 = U_1 * U_2$ where $U_1$ is the value for current health, $U_2$ is the original value of the scenario, and $U_3$ is the chained value (see equations (3) and (4)). Table 2 compares chained valuations of the scenarios by the direct method with valuations using the QALY algorithm.

U (BMT) * 2 (3)

U (EVAR) * 3 (4)

Because of the skewed nature of the data, the results of the t-test were confirmed by the Wilcoxon-sign test. Both statistical tests found significant differences between direct and QALY valuations of the BMT and EVAR scenarios ($p < 0.01$). The QALY method consistently gave higher valuations for both scenarios. The paired t-test and Wilcoxon-sign test were also used to determine whether there were significant differences between the valuations for two scenarios within each method. There were significant differences between the scenarios for the direct method, with EVAR scoring higher than BMT ($p$ < 0.01). However, for the QALY valuations the differences between scenarios were not significant ($p$ > 0.90 for t-test, and $p$ > 0.45 for Wilcoxon-sign test).

| Table 2 Scenario values with direct values chained to full health. | | | | |
|---|---|---|---|---|
| | Scenarios | | | |
| | BMT | | EVAR | |
| | Direct | QALY | Direct | QALY |
| Mean | 1.57 | 1.84 | 1.36 | 1.84 |
| SD | 0.42 | 0.28 | 0.54 | 0.39 |
| $25^{th}$ percentile | 1.38 | 1.91 | 1.04 | 1.55 |
| Median | 1.74 | 1.91 | 1.44 | 1.92 |
| $75^{th}$ percentile | 1.86 | 1.96 | 1.86 | 2.14 |
| Minimum | 0.53 | 0.71 | -0.50 | 1.03 |
| Maximum | 1.92 | 1.96 | 2.00 | 2.38 |
| t | 6.81 | | 6.46 | |
| t-test $p$ | 0.00 | | 0.00 | |
| CI lower | 0.19 | | 0.33 | |
| CI upper | 0.35 | | 0.63 | |
| Z | -6.40 | | -5.02 | |
| Wilcoxon-sign $p$ | 0.00 | | 0.00 | |
| N | 54 | 54 | 54 | 54 |

Figure 4 plots QALY and direct chained valuations for BMT and EVAR. The correlation between QALY and direct chained valuations for BMT is 0.71. For EVAR the correlation between the two methods is 0.35.

*Analysis of risk attitudes*

There was a mean $r$ of 1.21 (where r<1 indicates risk aversity, r=1 indicates risk neutrality, and r>1 indicates risk seeking), indicating that on average this sample had a tendency to be risk-seeking. Figure 5 plots mean certainty equivalences obtained from the risk questions. The straight line is how a risk neutral individual would be plotted. At U = 0.25 it would be 9 months; at U = 0.50 it would be 18 months; and at U = 0.75 it would be 27 months. The non-straight line is a plot of the mean values provided by the study sample. This plot shows that the sample tended to be more risk averse over the earlier part of the 36 months, and more risk seeking over the latter part.

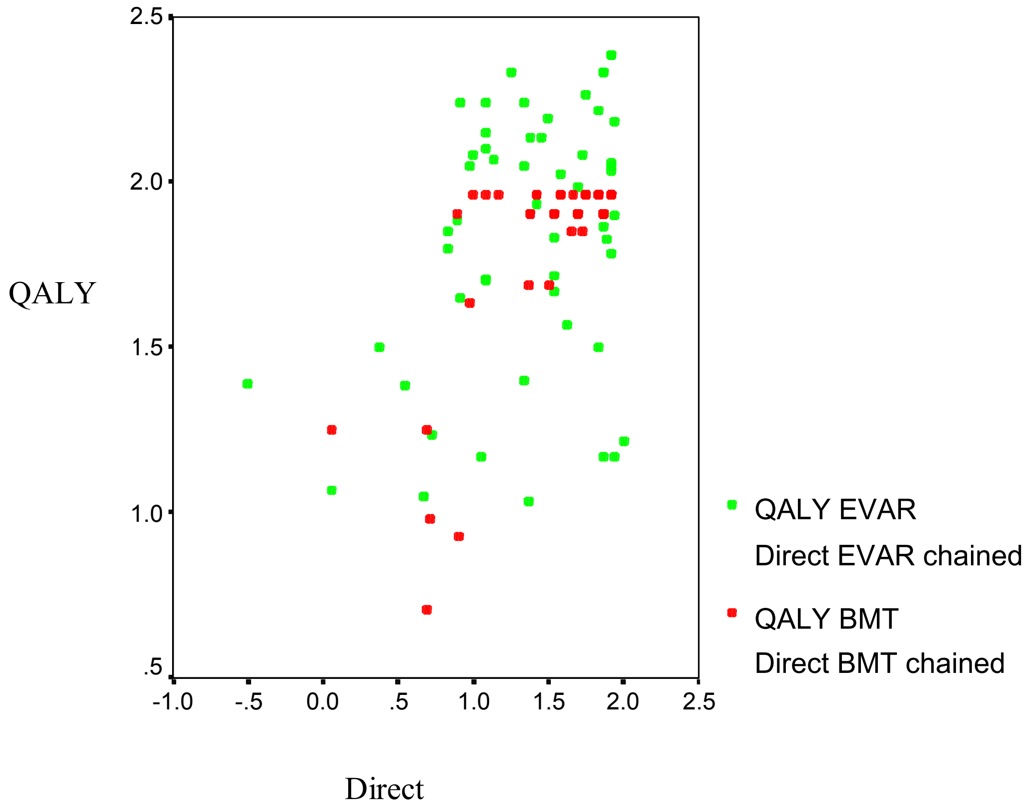



Figure 4  QALY BMT and EVAR plotted against direct chained to full health.

There were 16 respondents with $r < 1$ (0.422 – 0.981), 3 respondents with $r = 1$ (1.000 – 1.002), and 31 respondents with $r > 1$ (1.012 – 3.525). There were 3 respondents with $r = 37.255$, who gave values of 35 to their risk attitude questions. Thus they were not willing to trade at all for the risk attitude questions. These three were excluded from the calculation as outliers.

Miyamoto and Eraker (1985) suggest that risk averse people should prefer interventions with higher short-term survival, whereas risk seekers should prefer interventions with high short-term mortality if they have a higher expected longer term survival. If this sample is split into risk averse and risk seekers (excluding the three risk neutral respondents), the numbers in each group are rather small to perform reliable statistical tests. However, t-test and Wilcoxon-sign tests suggest that BMT is preferred to EVAR by the direct method for both risk averse and risk seekers ($p < 0.01$). There were no significant differences for QALY valuations.

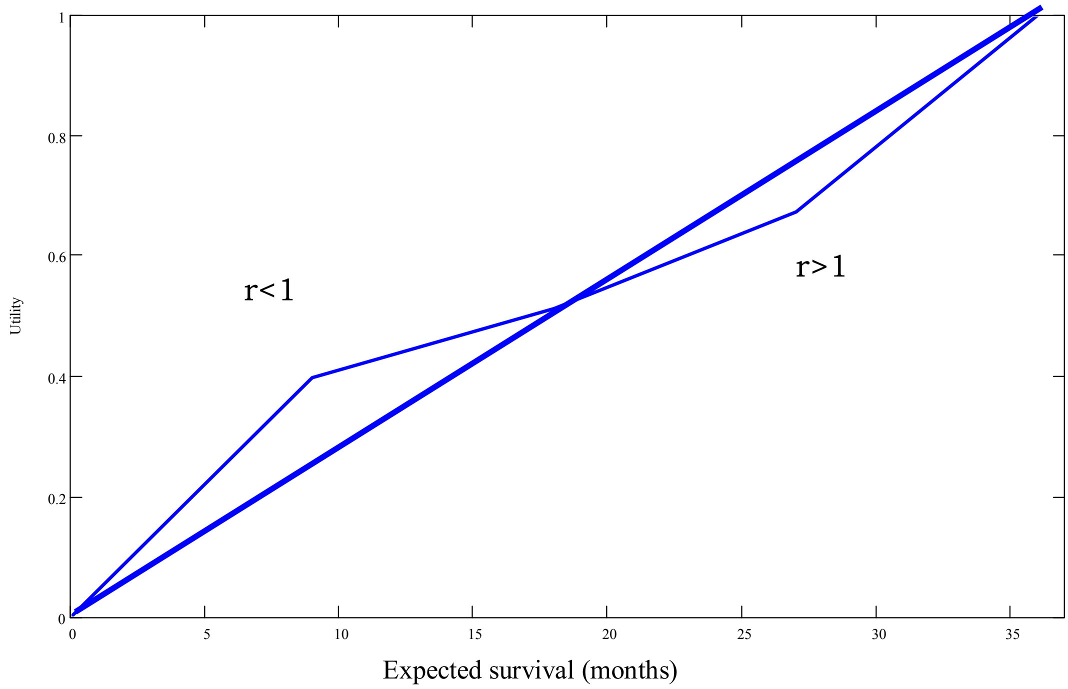



Figure 5 Mean risk attitude over expected survival.

Table 3 compares risk-adjusted scenarios for the QALY valuations with the direct valuations chained to full health. The risk adjustment equation $(x/t)^r$ was got from Miyamoto and Eraker (1985). N = 50 for risk-adjusted QALY scenarios because one respondent did not provide risk attitude information, and three had to be excluded because they had r > 37.

Table 3 Risk adjusted QALY values compared to direct chained values.

| | | BMT | EVAR |
|---|---|---|---|
| | $(x/t)^r$ | | |
| Mean | Direct (chained to full health) | 1.57 | 1.36 |
| (SD) | | (0.42) | (0.54) |
| Mean | QALY (risk-adjusted) | 2.63 | 2.72 |
| (SD) | | (1.85) | (2.80) |

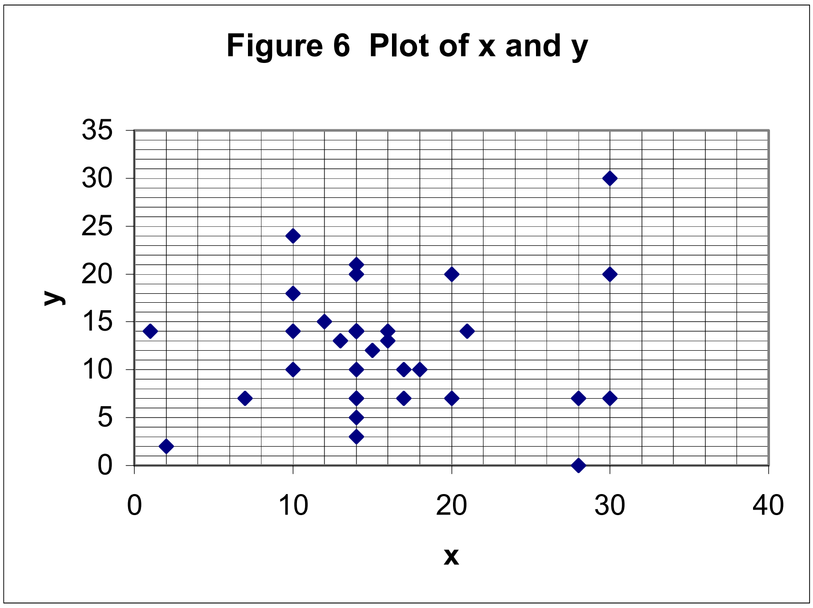
*Time preferences*

Table 4 shows the time preference statistics. The range of values given for *x* and *y* tends to lie between 1 and 30. However, there is one outlier value of 365 for *x*. If this person's value is included, there is an average strong negative time preference value for *x* (mean 21.74). However, when this outlier is excluded the mean value for *x* is 15.13. The 50$^{th}$ percentile value (median) is 14 whether or not the outlier is included. This is as expected, indicating a zero time preference.

Table 4 Time preference statistics.

| | Including outlier ($x$ = 365) | | | | | Excluding outlier ($x$ = 365) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Percentiles | | | | | | Percentiles | |
| | N | Mean (SD) | 25 | 50 | 75 | N | Mean (SD) | 25 | 50 | 75 |
| *x* | 53 | 21.74 (48.39) | 14 | 14 | 16 | 52 | 15.13 (5.75) | 14 | 14 | 15.75 |
| *y* | 53 | 13.15 (5.62) | 10 | 14 | 14 | 52 | 12.87 (5.27) | 10 | 14 | 14 |

Out of the 53 respondents to this question, 29 (54.7%) demonstrated neutrality of time preference for *x*, compared to 26 (49.1%) for *y*. As expected, the relationship between *x* and *y* does not appear to be linear (Figure 6). Supposing this question measures pure time preference, it would be expected that where $x < 14$ then $y > 14$ and *vice versa*. Likewise, when $x = 14$ then $y = 14$ also. Thus if the plot was linear, it would be a negative relationship. However, since around half of the sample are neutral, there would be a cluster around 14. Whereas there is a high correlation between the two variables when they are equal to 14, when they are not equal to 14 there is little correlation between them (correlation 0.07).




*Sensitivity analysis*

The results of the valuation method comparisons and risk attitude analysis have been shown to be robust to a sensitivity analysis, which took into account the wide ranges of indifference provided by 19 respondents.

**Discussion**

This study found that valuations of the BMT and EVAR scenarios by a direct method and the QALY algorithm produced different results. The QALY valuations were consistently higher than those obtained by the direct method. BMT was higher than EVAR when measured by the direct method. However, no significant differences were found between the two scenarios when valued by the QALY algorithm.

The results of the direct valuations seem to suggest that respondents placed a higher weight on the lower risk 24-month scenario than the EVAR scenario, which contained high risks of short-term mortality plus long-term morbidity in addition to the chance of surviving for 36 months in current health. Thus it would appear that this sample did not consider the 12-month extension of life expectancy worth the risks.

These are the kind of results one would expect from a risk averse population. However, the average risk attitude for this sample was r=1.21, indicating an average risk seeking attitude.

Preference for BMT over EVAR was upheld even when the sample was split into r<1 and r>1 categories. This is a violation of the axiom of constant attitude to risk, which underlies the QALY algorithm.

Although the difference levels of r favour BMT, the pattern of r in Figure 5 does lend some support to the suggestion of Miyamoto and Eraker (1985) that risk averse people should favour the BMT-type scenario, whereas risk seekers should prefer the EVAR-type scenario. This sample tend to be risk averse for short-term expected survival, and risk seeking over longer term expected survival.

The results of adjusting QALY values for risk attitude (Table 3) seem unrealistic. It is perhaps illegitimate to apply the mean r value in this way as r is so variable.

The results of this study throw doubt on the validity of using the Cairns and van der Pol method to measure time preferences over the short time horizon used in this study. Respondents often gave positive time preferences for one question but negative time preferences for the other question. This suggests that their responses were affected by sequence effects. This suggestion was supported by the comments of one respondent who said that he would prefer the ill state to be later rather than sooner, but that he would not wish it to be too close to his death. Although the questions were adapted from Cairns and van der Pol (2000), these findings do not necessarily cast doubt on their work as their scenarios were not over such a short life expectancy.

In this study BMT was found to be equal in utility to EVAR by the QALY algorithm. As the less expensive intervention, it would therefore be the treatment of choice. BMT was found to give greater utility than EVAR by the direct method. Again, BMT would be the treatment of choice. It is clear that in this case the two methods lead to the same resource allocation. However, the direct method gave utilities for both interventions which were significantly lower than those suggested by the QALY algorithm. Such differences could be important in other areas of medicine, and it is important to do further research comparing the QALY algorithm with direct methods of valuing health scenarios.

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